

SIDE AIR BAG OUT-OF-POSITION TESTING OF RECENT MODEL YEAR VEHICLES

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ABSTRACT

Side air bags are becoming more of a standard feature in the emerging vehicle fleet. These systems appear to offer superior protection in side crashes. Vehicle manufacturers are increasingly adding larger curtains that cover the entire window and two or three rows of seating. Currently, there are not any Federal Motor Vehicle Safety Standards (FMVSS) performance requirements related to the side out-of-position (OOP) performance with respect to side air bags. Therefore, the National Highway Traffic Safety Administration (NHTSA) conducted research tests to monitor this performance in both the front seat and rear seat positions where side air bags deploy.

The NHTSA has been monitoring this performance in recent model years, guided by the Technical Working Group (TWG) Procedures, a document that describes a voluntary set of OOP procedures with the main focus on side air bags, primarily in the front seats. This study uses the Hybrid III 3-year-old, 6-year-old and SID-IIIs (5th percentile adult female side impact dummy) dummies in different OOP test modes for all rows in the vehicle. The dummy responses from tests of side air curtains were all below the injury assessment reference values (IARVs). The dummy responses from tests of door and seat-mounted side air bags were also generally below the IARVs, but some OOP orientations in some vehicles did result in responses that were elevated or exceeded the IARVs.

As more vehicles add side air bags as standard features, the NHTSA is monitoring vehicles through Vehicle Safety Research (VSR) and the New Car Assessment Program (NCAP). The agency will continue to monitor how the air bags are affecting the OOP occupants in all near-side seating positions as air bag technology changes resulting from voluntary and federal upgrades. Currently, the NHTSA relies on the manufacturers to provide voluntary feedback on whether they have passed the TWG procedures, in addition to the testing done by VSR and NCAP.

INTRODUCTION

Side air bags started emerging in the vehicle fleet in the mid-to-late 1990s for side occupant protection. In 1999, the NHTSA asked the Alliance of Automobile Manufacturers (Alliance) and the Association of International Automobile Manufacturers (AIAM) to develop a guideline for vehicle manufacturers to assess the risks associated with side air bags and children. The procedures they produced, along with the Insurance Institute of Highway Safety (IIHS) and the Automotive Occupant Restraints Council (AORC), were the "Recommended Procedures for Evaluating Occupant Injury Risk from Deploying Side Air Bags" [1]. This set of guidelines was released to the public in August of 2000.

The NHTSA studied these procedures by procuring several vehicles and conducting numerous tests in both the front and rear seating positions along with various child restraints. The original study used a Hybrid III 3-year-old, 6-year-old, 12-month-CRABI, and a SID-IIIs Build Level C dummy. The NHTSA used the Technical Working Group (TWG) procedures as a guideline and recommended several changes to the TWG. These results were documented in the 2001 ESV paper of reference 2. In July of 2003, the TWG document was updated with some of the changes and is currently being used as a guideline by both the NHTSA and the manufacturers for side air bag OOP testing.

In December of 2003, the Auto Alliance announced a voluntary commitment to enhance protection for occupants in side-struck vehicles by improving head protection, which includes making side curtains standard features in most vehicles [3]. In May of 2004, a Notice of Proposed Rulemaking (NPRM) was issued to upgrade the current FMVSS Number 214 "Side Impact Protection". The proposed rule will upgrade the current test procedure and also add an additional side impact test, the oblique pole test.

Manufacturers may need to add or enhance the current side occupant protection designs. This may or may not include side air bags, including roof rail or curtain air bags.

The NHTSA is monitoring these changes to vehicles, especially in the second and third rows of the vehicles. The results presented in this paper are from a small sample of the vehicle fleet from MY2000, MY2004, and MY2005. The OOP tests were conducted by using the TWG procedures as a baseline for the testing and adding additional tests where deemed necessary.

TEST MATRIX

Vehicle Selection – Table 1 shows the vehicles chosen for this study and the styles of air bags and their location.

Table 1.
Vehicle Selection

Seat Mounted		Door Mounted	Roof Mounted
Thorax bags	Head/Thorax bags	Thorax bags	Head Bags
2004 Honda Accord	2005 Subaru Forester	2000 BMW 528i (Front and rear)	2000 BMW 528i (Front only)
2004 Volvo XC90	2005 Saab 93 Convertible		2004 Honda Accord
2004 Toyota Sienna			2004 Volvo XC90*
2005 VW Jetta			2004 Toyota Sienna*
2005 Honda CRV			2005 VW Jetta
2005 Toyota Corolla			2005 Honda CRV
2005 Ford 500			2005 Toyota Corolla
			2005 Ford 500

* These vehicles have curtain air bags that cover the 3rd row.

The MY2004 and 2005 vehicles chosen were based on sales, style and safety features. The 2000 BMW

528i used in this study was an original test vehicle used in the previous 2000 study.

All of the vehicles had air curtains and thoracic bags, except for the 2005 Subaru Forester and 2005 Saab 93 convertible. These two vehicles were equipped with combination (head and thorax) air bags.

The 2004 Volvo XC90 and 2004 Toyota Sienna were the only two vehicles in the test matrix that had a third row and that had an air curtain that reached its third row occupant area.

MY2000

The 2000 BMW 528i had thoracic door-mounted air bags in both the front and rear seats. The roof-mounted air bag was a tubular inflatable head protection system that only deployed in the front occupant area. This vehicle was tested using only the SID-II's dummy because the previous study tested with the Hybrid III 3- and 6-year old dummies. [2]

MY2004

There were three vehicles in the MY2004 test matrix: Honda Accord, Toyota Sienna, Volvo XC90. The focus of the testing was to compare how the TWG positions could be used in other rows. All three vehicles had thoracic seat mounted air bags in the front seats and roof-mounted air bags that spanned all of the rows. The 2004 Toyota Sienna had 2nd and 3rd rows with adjustable seat backs. The curtain spanned all three rows. The Volvo XC90 had 2nd and 3rd rows with non-adjustable seat backs. The curtain spanned the front and 2nd rows, and it also had a separate curtain that covered the 3rd row only.

MY2005

The vehicles used in the MY2005 test matrix were a Volkswagen Jetta, Honda CRV, Toyota Corolla, Ford 500, Subaru Forester and Saab 93 convertible. The testing conducted with the MY2005 vehicles focused on the rear seats and how the roof rail mounted air bags affected the occupants. The thoracic air bags in the front seats were also tested. Four of the six vehicles used in the study had an air curtain. The other two vehicles had a combination seat-mounted air bag.

Test Setup

All of the TWG procedures were used, except the thoracic seat-mounted position for a Hybrid III 3-year-old, TWG 3.3.3.4 - Lying on the seat. This test mode was not tested because the thoracic bags would only slightly touch the dummy when fully inflated and were therefore deemed unnecessary for this testing.

**Table 2.
Test Matrix**

			Vehicles									
			2004 Honda Accord	2004 Volvo XC90	2004 Toyota Sienna	2005 Subaru Forester	2005 VW Jetta	2005 Honda CRV	2005 Toyota Corolla	2005 Ford 500	2005 Saab 93 Conv.	2000 BMW 528i
Right Front Seat Thoracic Air Bag	3YO	TWG 3.3.3.1 Fwd Facing on Booster Block	X	X	X	X	X	X	X	X	X	n/a
	3YO	TWG 3.3.3.2: Rwd Facing (peek-a-boo)	X	X	X	X	X	X	X	X	X	n/a
	3YO	TWG 3.3.3.3: Head on Armrest	X	X	X	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	3YO	TWG 3.3.3.4: Lying on Seat	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Right Front Seat Thoracic Air Bag	6YO	TWG 3.3.3.5: Fwd Facing on Booster Block	X	X	X	X	X	X	X	X	X	n/a
	SIDIIs	TWG 3.3.3.6: Inboard Facing	X	X	X	X	X	X	X	X	X	X
Roof Rail Front Seat Air Bag	6YO	TWG 3.3.5.1: Inboard Facing on Booster Block	X	X	X	n/a	X	X	X	X	n/a	
	SIDIIs	TWG 3.3.5.2: Fwd Facing on Raised Seat	X	X	X	n/a	X	X	X	X	n/a	X
	SIDIIs	TWG 3.3.5.3: Inboard Facing on Raised Seat	X	X	X	n/a	X	X	X	X	n/a	X
Roof Rail 2nd Row Seating	3YO*	Back Against Door	n/a	n/a	X	n/a	X	X	X	X	n/a	n/a
	3YO*	On Knees Looking Out	n/a	n/a	X	n/a	X	X	X	X	n/a	n/a
	3YO*	Leaning Sideways on Booster	n/a	n/a	n/a	n/a	X	X	X	X	n/a	n/a
	6YO	TWG 3.3.5.1: Inboard Facing on Booster Block	X	X	X	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	6YO*	Leaning Sideways on Booster	n/a	n/a	n/a	n/a	X	X	X	X	n/a	n/a
	SIDIIs	TWG 3.3.5.2: Fwd Facing	X	X	X	n/a	n/a	n/a	n/a	n/a	n/a	X
Roof Rail 3rd Row Seating	3YO*	Back Against Door	n/a	n/a	X	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	3YO*	On Knees Looking Out	n/a	n/a	X	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	6YO	TWG 3.3.5.1: Inboard Facing on Booster Block	n/a	X	X	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	SIDIIs	TWG 3.3.5.2 Fwd Facing	n/a	X	X	n/a	n/a	n/a	n/a	n/a	n/a	n/a

*NHTSA Procedures

The setup for the right front passenger seat followed the TWG guidelines as follows: Seat in the lowest and rearmost position unless there was interference with the B-Pillar, in which case the seat was moved forward to avoid this interference. The seat back angle was set at the manufacturer's design or 25 degrees. The Toyota Sienna had adjustable seat backs in the 2nd and 3rd rows, which were adjusted 3 notches rearward when testing with the SID-II's dummy. Otherwise, they were tested in the full upright position.

Test Positions - The test configurations were based on the TWG document, July 2003. When the TWG guidelines were written, they focused mainly on the front seat occupant and thoracic style of air bags. Curtain air bags were relatively new when the procedures were first written. They now are common features in the existing fleet and deploy into more than one row. This study looked at the front passenger seat as well as the 2nd and 3rd rows.

The TWG procedures were slightly modified when used in the 2nd and 3rd rows of the vehicles. Table 2 shows the test matrix, and Appendix A has a brief summary of the TWG test procedures.

NHTSA Positions – The TWG document does not have any recommended test procedures for the roof rail system with a Hybrid III 3-year old and is limited to only one test mode for the Hybrid III 6-year-old. In order to fully evaluate the roof rail systems, the NHTSA tested using a few more seating positions. The new seating positions were based on the TWG thoracic seating positions.

The new positions were for the roof rail system for the 2nd and 3rd rows were as follows:

3YO Back Against Door on Booster Block:

Sitting perpendicular to the vehicle door on a foam booster block with the back against the door and with the center of gravity of the head aligned with roof rail air bag opening (Figure 1).



Figure 1. 3YO Back Against Door on Booster Block.

3YO On Knees Looking Out Side Window:

Kneeling, facing out the window, and leaning against door or side window with the center of gravity of the head aligned with the roof rail air bag opening (Figure 2).



Figure 2. 3YO On Knees Looking Out Side Window.

3YO Leaning Sideways on Booster Block:

Sitting on a foam booster block with back against the seat back, with the dummy's head leaning sideways, aligning the center of gravity of the head with the roof rail air bag opening (Figure 3).



Figure 3. 3YO Leaning Sideways on Booster Block.

6YO Leaning Sideways on Booster Block:

Sitting on a foam booster block with back against the seat back, with the dummy's head leaning sideways, aligning the center of gravity of the head with the roof rail air bag opening (Figure 4).



Figure 4. 6YO Leaning Sideways on Booster Block.

The objective was to gather more information on how small occupants react with the curtain style air bags in various positions in the rear seats. See Appendix A for the details of the new seating positions.

Dummy Instrumentation

The Hybrid III 3- and 6-year-old dummies are frontal impact dummies, and the SIDIIs is a side impact dummy. There are no federalized 3-or 6-year-old side impact dummies available. These are the dummies suggested for use in the TWG guidelines.

The Hybrid III 3- and 6-year-old dummies used in the testing had the following instrumentation: accelerometers in the head, shoulder, chest, ribs,

spine and pelvis; upper and lower 6-axis neck load cells; and a chest displacement potentiometer.

The SIDIIs dummy was instrumented with the following: accelerometers in the head, shoulders, chest, ribs, spine, and pelvis; load cells in the upper and lower neck and shoulder; and displacement potentiometers in the ribs and chest. The study started with the FRG (floating rib guide) dummy (tests SIDIIs_001-018) and finished with Build Level D dummy (SIDIIs_019-037).

Injury Criteria (IARVs)

Table 3 shows the corresponding injury assessment reference values (IARVs) used to determine the probability for injury for each of the dummies. The values represent approximately a 5 percent risk of AIS 4 or greater injury for the head and thorax and an AIS 3 or greater injury for the neck [1]. For each test, the calculated values for 15ms Head Injury Criterion (HIC) and Neck Injury Criterion (Nij), along with the measured peak values for chest deflection, rib deflection, and neck tension and compression were evaluated based on their respective IARV. See the Tables in Appendix B for the normalized dummy responses for each dummy and test configuration.

TABLE 3.
Injury Assessment Reference Values (IARV)

	15ms HIC	Chest/ Rib* Def. (mm)	Nij	Neck Tension (N)	Neck Comp. (N)
3YO	570	36	1.0	1130	1380
6YO	723	40	1.0	1490	1820
SIDIIs	779	34	1.0	2070	2520

*Rib Deflection used for SIDIIs

TEST RESULTS

There were 96 tests conducted on ten vehicles using three dummies, and three test configurations exceeded one or more IARV. These results were with the Hybrid III 3-year-old and/or 6-year old dummies, and all of these were from the thoracic air bags. There were seven other tests that had elevated responses (above 80% of the normalized IARV), but did not exceed an IARV. The test data with the normalized responses are shown in Appendix B.

Thoracic Air Bags (seat and door mounted):

All of the vehicles used in this study had a type of thoracic air bag for the front occupant. Seven of the ten vehicles had a thoracic only seat mounted air bag that was located in the front seats. One vehicle, the

2000 BMW 528i, had thoracic door mounted air bags in the front and rear doors (Figure 5). The other two vehicles, a 2005 Subaru Forester and 2005 Saab 93 convertible had a combination air bag located in the front seat (Figure 6). Of the 42 tests conducted with thoracic air bags, only three tests exceeded the IARV and seven tests had elevated responses in the chest and/or rib deflection or with the neck injury. All of the 15ms HIC values were negligible.



Figure 5. 2000 BMW 528i Door Mounted Air Bag.

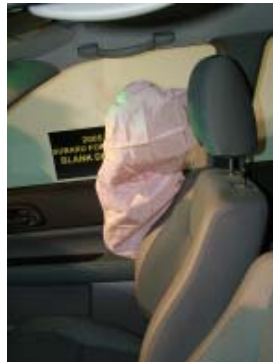


Figure 6. 2005 Subaru Forester Combination Air Bag.

TWG 3.3.3.1 (Figure 7) places the Hybrid III 3-year-old against the seat edge with its head/neck junction at the top edge of the air bag module. This test mode produced neck responses that were elevated or exceeded the IARV in one of the nine vehicles tested in this mode. The Hybrid III 3-year-old exceeded the neck tension IARV and had an elevated Nij response in the test mode TWG 3.3.3.1 for the 2005 Honda CRV. As the air bag deployed it punched through the seat cover and caused direct loads onto the neck.



Figure 7. Hybrid III 3-year-old Position TWG 3.3.3.1.

TWG 3.3.3.2 (Figure 8) places the chest at the top edge of the air bag module. It also produced higher responses, with four of the nine vehicles having chest

deflections, Nij, or Neck Tension responses that were elevated or that exceeded the IARV.



Figure 8. Hybrid III 3-year-old Position TWG 3.3.3.2.

The Hybrid III 3-year old exceeded the chest deflection IARV in the 2005 Subaru Forester test with a normalized response of 1.03. The 2004 Volvo XC90 had elevated response in the front passenger seat for the chest deflection, Nij, and neck tension with normalized response values of 0.88, 0.87, and 0.97, respectively. The 2005 Ford 500 had an Nij response of 0.84, while the chest deflection for the 2004 Toyota Sienna was 0.90. As the air bag emerges from the seat, the dummy's chest is directly loaded causing higher responses.

TWG 3.3.3.5 places the Hybrid III 6-year-old dummy's neck/torso junction with the top edge of the air bag module. The 2005 Subaru Forester exceeded the Nij response and the 2004 Honda Accord had an elevated response with this test mode. As the air bag was deployed, the torso moved forward and the neck was put into extension. Figure 9 shows the Hybrid III 6-year-old during the Subaru Forester test. Similar dummy kinematics were also seen with the Hybrid III 3-year-old in the test mode of TWG 3.3.3.1.



Figure 9. Hybrid III 6YO (Test no. 6YO_015) With Deploying Air Bag.

The 2000 BMW 528i was only tested with the SID-IIs dummy, which resulted in elevated responses of the rib deflection for both the front and rear door mounted air bags, test condition TWG 3.3.4.5.

The two vehicles that exceeded the IARV responses were 2005 Subaru Forester and 2005 Honda CRV. These vehicles were certified by the manufacturer, and reported to the NHTSA, as meeting all of the qualified TWG guidelines [6]. Further research and comparison testing would be needed to explain the different results.

Curtain Air Bags (roof rail mounted):

There were 54 tests conducted on eight vehicles with the roof rail systems resulting in low response values (below 70% of all of the IARVs). Thirty-two tests were conducted with the Hybrid III 3-year-old and 6-year old dummies. Twenty-two of the tests were conducted with the SID-IIs dummy. The 15ms HIC responses were negligible for all three dummies.

The new NHTSA procedures used with the Hybrid III 3-year-old and 6-year-old dummies, positioned the heads in various locations. All the normalized responses were below 60% of the Nij IARV values. The 2004 Toyota Sienna Hybrid III 3-year-old NHTSA position “Back against door” in the second row had the highest response with a 0.60 Nij response value.

The Hybrid III 6-year-old and SID-IIs dummies were tested in all three rows of the 2004 Volvo XC90 and Toyota Sienna. The test modes were TWG 3.3.5.1 and TWG 3.3.5.2. The dummies were positioned according to the TWG guidelines in all three rows, which typically placed the head in the same lateral plane in all three rows. The air bag produced similar responses when tested with the same dummy and same seating positions for the various rows.

The 2004 Toyota Sienna had a curtain that spanned all three rows. The Nij responses for the Hybrid III 6-year-old dummy were similar for all three rows. When tested with the SID-IIs dummy, the 2nd row produced slightly lower responses for both the Nij and Neck Compression. (Figure 10)

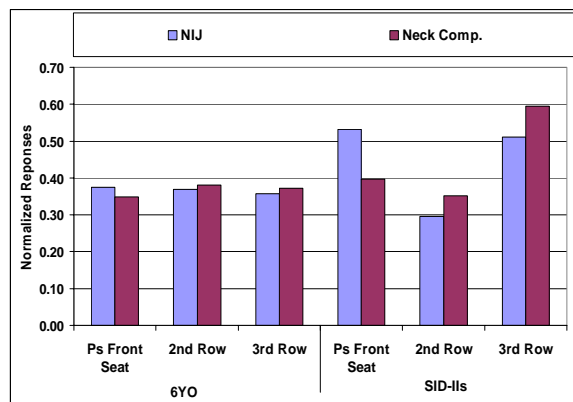


Figure 10. Hybrid III 6YO TWG 3.3.5.1 and SID-IIs TWG 3.3.5.2 Responses for the 2004 Toyota Sienna.

The 2004 Volvo XC90 produced similar findings except that the 3rd row positions produced higher results than the 1st and 2nd rows (Figure 11). There is an individual curtain for the 3rd row that is deployed at the same time as the 1st and 2nd row curtain. See Figures 12 and 13.

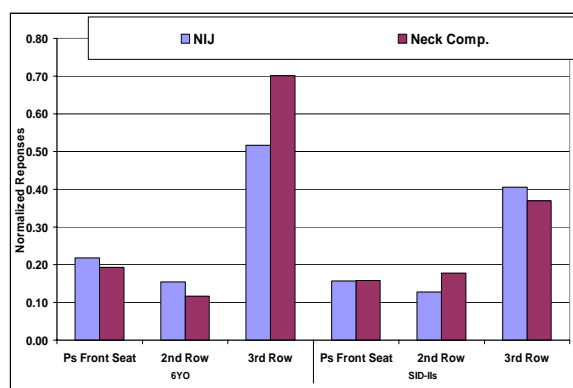


Figure 11. Hybrid III 6YO TWG 3.3.5.1 and SID-IIs TWG 3.3.5.2 Responses for the 2004 Volvo XC90.



Figure 12. 2004 Volvo XC90 2nd row curtain.



Figure 13. 2004 Volvo XC90 3rd row curtain.

Five vehicles were tested by positioning the SID-IIs dummy in the test condition TWG 3.3.5.2 with the curtain and the thoracic air bags both deployed. This resulted in one vehicle, the 2000 BMW 528i, with an elevated response in the rib deflection. This elevated

response was from the thoracic bag and not the curtain bag.

In some instances, the curtain pushed the dummy toward the side window, which placed the dummy in between the side window and the curtain (Figure 14). This occurred in approximately 30% of the roof rail tests conducted. The vehicles in which this result occurred were the 2004 Honda Accord, 2005 Toyota Corolla, 2005 VW Jetta, and 2005 Honda CRV.

This may be a finding that will require further investigation of OOP testing conditions and how the dummy is positioned for the curtain test. Currently, the center of gravity of the dummy's head is aligned with the deployment path of the roof rail module. Therefore, the trajectory of the dummy upon curtain deployment may be sensitive to the precise impact location relative to the dummy head center of gravity. In that case, just slight variations in dummy positioning or the direction of curtain deployment may affect the outcome.



Figure 14. Curtain deployments in different vehicles with the different dummies.

OBSERVATIONS

Even though there is not an FMVSS performance requirement for side air bags, the out of position testing showed these air bags generally should not produce serious injury to small occupants in all rows of the vehicle. Ninety-seven percent (97%) of the

tests conducted met or passed all of the proposed injury values.

Of the 42 tests conducted with thoracic air bags, only three tests exceeded an IARV, and seven other tests had elevated responses in the chest and/or rib deflection or with the neck injury.

Two of the three tests that exceeded an IARV were with the Hybrid III 3-year-old in the 2005 Honda CRV and the 2005 Subaru Forester. The third was with the Hybrid III 6-year-old, also in the Forester.

The curtain or roof rail mounted air bags produced relatively low numbers in all rows with all three dummies. The 15ms HIC values were negligible in this testing for all three dummies. The neck injury values were somewhat higher, but still relatively low. The highest Nij and neck tension values were 60% and 70% of the IARV, respectively.

The curtain air bags in the 2004 Volvo XC90 and Toyota Sienna generally produced similar results between the rows when tested with the SID-IIIs and Hybrid III 6-year-old dummies. The exception was the 3rd row air curtain in the Volvo, which was a separate bag than that for the first two rows. It produced neck responses somewhat higher than the curtain for the front rows.

The TWG seating procedure guidelines can be used in all the rows with little or no modifications. Additional test positions for the roof mounted air bags, such as the NHTSA procedures with the Hybrid III 3- and 6-year-old dummies introduced in this paper, would provide a more thorough OOP evaluation.

REFERENCES

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3. Alliance of Automotive Manufacturers, "Automakers Compatibility Commitment: Improving Everyone's Safety Through Voluntary Industry Cooperation", December 2003.

4. Department of Transportation Federal Register, "Federal Motor Vehicle Safety Standards; Side Impact Protection; Side Impact Phase-In Reporting Requirements", May 17, 2004.

5. NHTSA FMVSS 214, Side Impact Protection, <http://nhtsa.gov/cars/rules/standards/FMVSS-Regs/pages/TOC.htm>

6. NHTSA website, <http://safercar.gov/NCAP/>

APPENDIX A: SEATING GUIDELINES

The Technical Working Group Guidelines: “Recommended Procedures for Evaluating Occupant Injury Risk from Deploying Side Air Bagss”, July 2003 revision document was used in this research study. The following is a brief seating summary for reference purposes.

Tests Conducted following TWG guidelines:

Hybrid III 3YO

- TWG 3.3.3.1: Sitting on seat edge on a booster, with head neck junction aligned with the top edge of the air bag module
- TWG 3.3.3.2: Kneeling on seat edge facing rearward, upper rib aligned with the top edge of the air bag module
- TWG 3.3.3.3: Lying on seat, perpendicular to the door, with the head on the armrest, with the center of gravity of the head aligned with the vertical centerline of the air bag module.

Hybrid III 6YO

- TWG 3.3.3.5: Sitting on seat edge on a booster, with the lower neck junction aligned with the top edge of the air bag module
- TWG 3.3.5.1: Sitting on foam booster perpendicular to door, with the center of gravity of the head aligned with the deployment path of the roof mounted air bag

SID-IIs

- TWG 3.3.3.6: Sitting on the outboard seat edge, perpendicular to the door, with the center of the first rib aligned with the top of the air bag module.
- TWG 3.3.5.2: Sitting on the outboard seat edge facing forward, with the center of gravity of the head aligned with the deployment path of the roof mounted air bag; dummy may be leaning slightly outboard.
- TWG 3.3.5.3: Sitting perpendicular to the door at the outboard edge of seat, with the center of gravity of the head aligned with the deployment path of the roof module at the forward most point to minimize the vertical distance.

The new NHTSA Test Procedures were created using the TWG seating as a baseline. The following is a brief summary of how the dummies were seated.

Hybrid III 3YO and 6YO:

3YO Back Against Door on Booster Block: Sitting on a foam booster block, perpendicular to the vehicle door, with the back resting against the door, and with the center of gravity of the head aligned with the roof rail air bag opening.

3YO On Knees Looking Out Side Window: Kneeling, facing outward, and leaning against the door or side window with center of gravity of the head aligned with the roof rail air bag opening.

3YO Leaning Sideways on Booster Block: Sitting on a foam booster block, with back against the seat back and leaning sideways, with the center of gravity of the head aligned with the roof rail air bag opening.

6YO Leaning Sideways on Booster Block: Sitting on a foam booster block, with back against the seat back and leaning sideways, with the center of gravity of the head aligned with the roof rail air bag opening.

APPENDIX B: NORMALIZED RESPONSE TABLES

Table A: Hybrid III 3YO Normalized Test Results

Vehicle	Test Number	Test Position	Air bag deployed	Seating position	15ms HIC	Chest Def.(mm)	NIJ	Neck Tension(N)	Neck Comp.(N)
04 Honda Accord	3YOSOOP_01	TWG 3.3.3.1	Thoracic	Ps Front Seat	0.10	0.06	0.32	0.53	0.25
04 Toyota Sienna	3YOSOOP_07	TWG 3.3.3.1	Thoracic	Ps Front Seat	0.01	0.07	0.32	0.16	0.16
04 Volvo XC90	3YOSOOP_04	TWG 3.3.3.1	Thoracic	Ps Front Seat	0.11	0.08	0.57	0.37	0.28
05 Ford 500*	3YO_036	TWG 3.3.3.1*	Thoracic+Curtain	RT FR Seat	0.04	0.06	0.52	0.58	0.16
05 Honda CRV	3YO_038	TWG 3.3.3.1	Thoracic	RT FR Seat	0.12	0.13	0.95	1.04	0.17
05 Saab 93	3YO_028	TWG 3.3.3.1	Combination	RT FR Seat	0.04	0.09	0.53	0.59	0.15
05 Subaru Forester	3YO_035	TWG 3.3.3.1	Combination	RT FR Seat	0.09	0.11	0.73	0.54	0.22
05 Toyota Corolla*	3YO_031	TWG 3.3.3.1*	Thoracic+Curtain	RT FR Seat	0.03	0.03	0.28	0.19	0.07
05 VW Jetta	3YO_033	TWG 3.3.3.1	Thoracic	RT FR Seat	0.01	0.04	0.28	0.25	0.04
04 Honda Accord	3YOSOOP_02	TWG 3.3.3.2	Thoracic	Ps Front Seat	0.00	0.37	0.32	0.29	0.04
04 Toyota Sienna	3YOSOOP_08	TWG 3.3.3.2	Thoracic	Ps Front Seat	0.00	0.90	0.36	0.42	0.06
04 Volvo XC90	3YOSOOP_05	TWG 3.3.3.2	Thoracic	Ps Front Seat	0.12	0.88	0.87	0.97	0.14
05 Ford 500	3YO_037	TWG 3.3.3.2	Thoracic	RT FR Seat	0.02	0.70	0.84	0.74	0.01
05 Honda CRV	3YO_039	TWG 3.3.3.2	Thoracic	RT FR Seat	0.00	0.15	0.25	0.17	0.05
05 Saab 93	3YO_030	TWG 3.3.3.2	Combination	RT FR Seat	0.01	0.48	0.58	0.37	0.03
05 Subaru Forester	3YO_015	TWG 3.3.3.2	Combination	RT FR Seat	0.04	1.03	0.49	0.64	0.06
05 Toyota Corolla	3YO_032	TWG 3.3.3.2	Thoracic	RT FR Seat	0.00	0.08	0.19	0.10	0.02
05 VW Jetta	3YO_034	TWG 3.3.3.2	Thoracic	RT FR Seat	0.01	0.36	0.67	0.45	0.16
04 Honda Accord	3YOSOOP_03	TWG 3.3.3.3	Thoracic	Ps Front Seat	0.02	0.01	0.10	0.10	0.10
04 Toyota Sienna	3YOSOOP_09	TWG 3.3.3.3	Thoracic	Ps Front Seat	0.00	0.00	0.05	0.06	0.03
04 Volvo XC90	3YOSOOP_06	TWG 3.3.3.3	Thoracic	Ps Front Seat	0.01	0.01	0.13	0.24	0.07
04 Toyota Sienna -	3YO_011	Back against Door	Curtain	2nd Row Seat	0.01	0.01	0.60	0.04	0.48
04 Toyota Sienna -	3YO_010	Back against Door	Curtain	3rd Row Seat	0.00	0.01	0.22	0.03	0.19
05 Ford 500	3YO_025	Back against Door	Curtain	RT RR Seat	0.01	0.01	0.30	0.01	0.11
05 Honda CRV	3YO_019	Back against Door	Curtain	RT RR Seat	0.01	0.01	0.14	0.03	0.17
05 Toyota Corolla	3YO_022	Back against Door	Curtain	RT RR Seat	0.01	0.01	0.14	0.05	0.18
05 VW Jetta	3YO_016	Back against Door	Curtain	RT RR Seat	0.01	0.00	0.08	0.03	0.07

Exceeds IARV

Elevated Response (80% to 99% of IARV)

Under 80% of IARV

APPENDIX B: NORMALIZED RESPONSE TABLES

Table A: Hybrid III 3YO Normalized Test Results Continued

Vehicle	Test Number	Test Position	Air bag deployed	Seating position	15ms HIC	Chest Def.(mm)	NIJ	Neck Tension(N)	Neck Comp.(N)
05 Ford 500	3YO_027	Leaning Sideways on Booster	Curtain	RT RR Seat	0.00	0.06	0.20	0.00	0.28
05 Honda CRV	3YO_021	Leaning Sideways on Booster	Curtain	RT RR Seat	0.01	0.01	0.07	0.00	0.01
05 Toyota Corolla	3YO_024	Leaning Sideways on Booster	Curtain	RT RR Seat	0.00	0.00	0.10	0.05	0.08
05 VW Jetta	3YO_018	Leaning Sideways on Booster	Curtain	RT RR Seat	0.00	0.01	0.25	0.02	0.21
04 Toyota Sienna -	3YO_012	On knees looking out	Curtain	2nd Row Seat	0.01	0.00	0.28	0.03	0.31
04 Toyota Sienna -	3YO_013	On knees looking out	Curtain	3rd Row Seat	0.00	0.00	0.11	0.04	0.12
05 Ford 500	3YO_026	On knees looking out	Curtain	RT RR Seat	0.00	0.00	0.14	0.01	0.14
05 Honda CRV	3YO_020	On knees looking out	Curtain	RT RR Seat	0.02	0.02	0.54	0.16	0.36
05 Toyota Corolla	3YO_023	On knees looking out	Curtain	RT RR Seat	0.02	0.01	0.32	0.04	0.43
05 VW Jetta	3YO_017	On knees looking out	Curtain	RT RR Seat	0.00	0.00	0.18	0.08	0.17
			Exceeds IARV	Elevated Response (80% to 99% of IARV)			Under 80% of IARV		

APPENDIX B: NORMALIZED RESPONSE TABLES

Table B: Hybrid III 6YO Normalized Test Results

Vehicle	Test Number.	Test Position	Air Bag Deployed	Seating position	15ms HIC	Chest Def.(mm)	NIJ	Neck Tension(N)	Neck Comp.(N)
04 Honda Accord	6YOSOOP_02	TWG 3.3.3.5	Thoracic	Ps Front Seat	0.01	0.05	0.80	0.28	0.27
04 Toyota Sienna	6YOSOOP_08	TWG 3.3.3.5	Thoracic	Ps Front Seat	0.00	0.04	0.25	0.04	0.12
04 Volvo XC90	6YOSOOP_03	TWG 3.3.3.5	Thoracic	Ps Front Seat	0.01	0.05	0.67	0.22	0.31
05 Ford 500	6YO_027	TWG 3.3.3.5	Thoracic	RT FR Seat	0.01	0.04	0.66	0.37	0.15
05 Honda CRV	6YO_028	TWG 3.3.3.5	Thoracic	RT FR Seat	0.01	0.02	0.64	0.20	0.12
05 Saab 93	6YO_024	TWG 3.3.3.5	Combination	RT FR Seat	0.01	0.04	0.46	0.33	0.06
05 Subaru Forester	6YO_015	TWG 3.3.3.5	Combination	RT FR Seat	0.07	0.09	1.20	0.47	0.39
05 Toyota Corolla	6YO_025	TWG 3.3.3.5	Thoracic	RT FR Seat	0.01	0.03	0.41	0.13	0.16
05 VW Jetta	6YO_026	TWG 3.3.3.5	Thoracic	RT FR Seat	0.00	0.01	0.22	0.04	0.15
04 Honda Accord	6YOSOOP_01	TWG 3.3.5.1	Curtain	Ps Front Seat	0.01	0.01	0.47	0.00	0.43
04 Honda Accord	6YOSOOP_05	TWG 3.3.5.1	Curtain	Ps Rear Seat	0.00	0.13	0.16	0.01	0.21
04 Toyota Sienna	6YOSOOP_07	TWG 3.3.5.1	Curtain	Ps Front Seat	0.04	0.01	0.38	0.01	0.35
04 Toyota Sienna	6YOSOOP_09	TWG 3.3.5.1	Curtain	2nd Row	0.01	0.01	0.37	0.20	0.38
04 Toyota Sienna	6YOSOOP_10	TWG 3.3.5.1	Curtain	3rd Row	0.00	0.00	0.36	0.00	0.37
04 Volvo XC90	6YOSOOP_06	TWG 3.3.5.1	Curtain	Ps Front Seat	0.00	0.00	0.22	0.01	0.19
04 Volvo XC90	6YOSOOP_04	TWG 3.3.5.1	Curtain	2nd Row	0.00	0.00	0.15	0.00	0.12
04 Volvo XC90	6YOSOOP_11	TWG 3.3.5.1	Curtain	3rd Row	0.05	0.01	0.52	0.00	0.70
05 VW Jetta	6YO_016	Back against Door	Curtain	RT RR Seat	0.00	0.01	0.19	0.06	0.16
05 Honda CRV	6YO_018	Back against Door	Curtain	RT RR Seat	0.01	0.01	0.27	0.01	0.24
05 Toyota Corolla	6YO_020	Back against Door	Curtain	RT RR Seat	0.00	0.01	0.17	0.04	0.23
05 Ford 500	6YO_022	Back against Door	Curtain	RT RR Seat	0.01	0.00	0.34	0.01	0.35
05 VW Jetta	6YO_017	Leaning Sideways on Booster	Curtain	RT RR Seat	0.01	0.01	0.22	0.02	0.25
05 Honda CRV	6YO_019	Leaning Sideways on Booster	Curtain	RT RR Seat	0.00	0.01	0.23	0.01	0.25
05 Toyota Corolla	6YO_021	Leaning Sideways on Booster	Curtain	RT RR Seat	0.01	0.01	0.20	0.01	0.29
05 Ford 500	6YO_023	Leaning Sideways on Booster	Curtain	RT RR Seat	0.00	0.00	0.43	0.01	0.51
			Exceeds IARV	Elevated Response (80% to 99% of IARV)			Under 80% of IARV		

APPENDIX B: NORMALIZED RESPONSE TABLES

Table C: SID-IIs Normalized Test Results

Vehicle	Test Number	Test Position	Air Bag	Seating position	15ms HIC	Rib Def. (mm)	NIJ	Neck Tension(N)	Neck Comp.(N)
04 Honda Accord	SOOP_SID2S_003	TWG 3.3.3.6	Thoracic	Ps Front Seat	0.00	0.22	0.18	0.06	0.08
04 Toyota Sienna	SOOP_SID2S_010	TWG 3.3.3.6	Thoracic	Ps Front Seat	0.00	0.29	0.09	0.06	0.06
04 Volvo XC90	SOOP_SID2s_018	TWG 3.3.3.6	Thoracic	Ps Front Seat	0.00	0.39	0.15	0.10	0.14
05 Subaru Forester	SIDIIIs_036	TWG 3.3.3.6 (LSC)	Combination	Ps Front Seat	0.00	0.39	0.22	0.18	0.07
05 Subaru Forester	SIDIIIs_037	TWG 3.3.3.6 (LSC)	Combination	Ps Front Seat	0.00	0.39	0.21	0.13	0.08
05 Ford 500	SIDIIIs_031	TWG 3.3.3.6 (LSC)	Thoracic	Ps Front Seat	0.00	0.05	0.10	0.06	0.06
05 Honda CRV	SIDIIIs_033	TWG 3.3.3.6 (LSC)	Thoracic	Ps Front Seat	0.00	0.30	0.09	0.07	0.08
05 Saab 93	SIDIIIs_032	TWG 3.3.3.6 (LSC)	Thoracic	Ps Front Seat	0.01	0.57	0.12	0.15	0.07
05 Toyota Corolla	SIDIIIs_035	TWG 3.3.3.6 (LSC)	Thoracic	Ps Front Seat	0.00	0.23	0.12	0.06	0.11
05 VW Jetta	SIDIIIs_034	TWG 3.3.3.6 (LSC)	Thoracic	Ps Front Seat	0.00	0.21	0.08	0.04	0.08
00 BMW 528i	SIDIIIs_019	TWG 3.3.4.5 (RSC)	Thoracic Door	Ps Front Seat	0.00	0.93	0.07	0.09	0.10
00 BMW 528i	SIDIIIs_020	TWG 3.3.4.5 (RSC)	Thoracic Door	Ps Rear Seat	0.05	0.88	0.21	0.51	0.17
04 Honda Accord	SOOP_SID2S_001	TWG 3.3.5.2	Curtain	Ps Front Seat	0.00	n/a	0.48	0.00	0.70
04 Toyota Sienna	SOOP_SID2S_008	TWG 3.3.5.2	Curtain	Ps Front Seat	0.01	n/a	0.53	0.02	0.40
04 Volvo XC90	SOOP_SID2s_005	TWG 3.3.5.2	Curtain	Ps Front Seat	0.00	n/a	0.16	0.01	0.16
04 Volvo XC90	SOOP_SID2s_013	TWG 3.3.5.2	Curtain	2nd Row	0.00	n/a	0.13	0.00	0.18
04 Volvo XC90	SOOP_SID2s_014	TWG 3.3.5.2	Curtain	3rd Row	0.02	n/a	0.41	0.01	0.37
04 Toyota Sienna	SOOP_SID2S_011	TWG 3.3.5.2	Curtain	2nd Row	0.00	n/a	0.30	0.02	0.35
04 Toyota Sienna	SOOP_SID2S_017	TWG 3.3.5.2	Curtain	3rd Row	0.02	n/a	0.51	0.00	0.59
05 Ford 500	SIDIIIs_029	TWG 3.3.5.2 (R S C)	Curtain + Thoracic	Ps Front Seat	0.00	0.13	0.09	0.05	0.21
05 Honda CRV	SIDIIIs_023	TWG 3.3.5.2 (R S C)	Curtain + Thoracic	Ps Front Seat	0.02	0.31	0.29	0.05	0.63
05 Toyota Corolla	SIDIIIs_025	TWG 3.3.5.2 (R S C)	Curtain + Thoracic	Ps Front Seat	0.01	0.01	0.11	0.14	0.25
05 VW Jetta	SIDIIIs_027	TWG 3.3.5.2 (R S C)	Curtain + Thoracic	Ps Front Seat	0.01	0.17	0.29	0.06	0.66
04 Honda Accord	SOOP_SID2S_015	TWG3.3.5.2	Curtain	Ps Rear Seat	0.00	n/a	0.14	0.01	0.16
04 Honda Accord	SOOP_SID2S_016	TWG3.3.5.2	Curtain	Ps Rear Seat	0.00	n/a	0.14	0.02	0.15
00 BMW 528i	SIDIIIs_021	TWG 3.3.5.2 (RSC)	Curtain + Thoracic	Ps Front Seat	0.02	0.88	0.34	0.02	0.63
04 Honda Accord	SOOP_SID2S_002	TWG 3.3.5.3	Curtain	Ps Front Seat	0.01	n/a	0.46	0.00	0.43
04 Toyota Sienna	SOOP_SID2S_009	TWG 3.3.5.3	Curtain	Ps Front Seat	0.07	n/a	0.28	0.01	0.34
04 Volvo XC90	SOOP_SID2s_006	TWG 3.3.5.3	Curtain	Ps Front Seat	0.00	n/a	0.18	0.01	0.25
00 BMW 528i	SIDIIIs_022	TWG 3.3.5.3 (RSC)	Curtain	Ps Front Seat	0.01	0.04	0.31	0.00	0.68
05 Ford 500	SIDIIIs_030	TWG 3.3.5.3 (RSC)	Curtain	Ps Front Seat	0.00	0.00	0.10	0.00	0.14
05 Honda CRV	SIDIIIs_024	TWG 3.3.5.3 (RSC)	Curtain	Ps Front Seat	0.01	0.01	0.16	0.04	0.28
05 Toyota Corolla	SIDIIIs_026	TWG 3.3.5.3 (RSC)	Curtain	Ps Front Seat	0.02	0.01	0.45	0.23	0.65
05 VW Jetta	SIDIIIs_028	TWG 3.3.5.3 (RSC)	Curtain	Ps Front Seat	0.01	0.01	0.27	0.01	0.62

Exceeds IARV

Elevated Response (80% to 99% of IARV)

Under 80% of IARV